



The Role of Heat Tolerance Testing in Recovery and Return to Duty

Maj. Yuval Heled, PhD

**The Institute of Military Physiology
Heller Institute of Medical Research
The IDF Medical Corps
Israel**

Report Documentation Page			Form Approved OMB No. 0704-0188	
<p>Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p>				
1. REPORT DATE 23 OCT 2008	2. REPORT TYPE N/A	3. DATES COVERED -		
4. TITLE AND SUBTITLE The Role of Heat Tolerance Testing in Recovery and Return to Duty			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) The Institute of Military Physiology Heller Institute of Medical Research The IDF Medical Corps Israel			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited				
13. SUPPLEMENTARY NOTES American college of Sports Medicine (ACSM/DOD)roundtable Conference, 22-23 Oct 2008., The original document contains color images.				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF: a. REPORT unclassified			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 31
b. ABSTRACT unclassified				
c. THIS PAGE unclassified				



Heat balance

Exercise



Heat
production



Heat gain



Hyperthermia



Heat dissipation:
Convection
Evaporation



Heat stroke



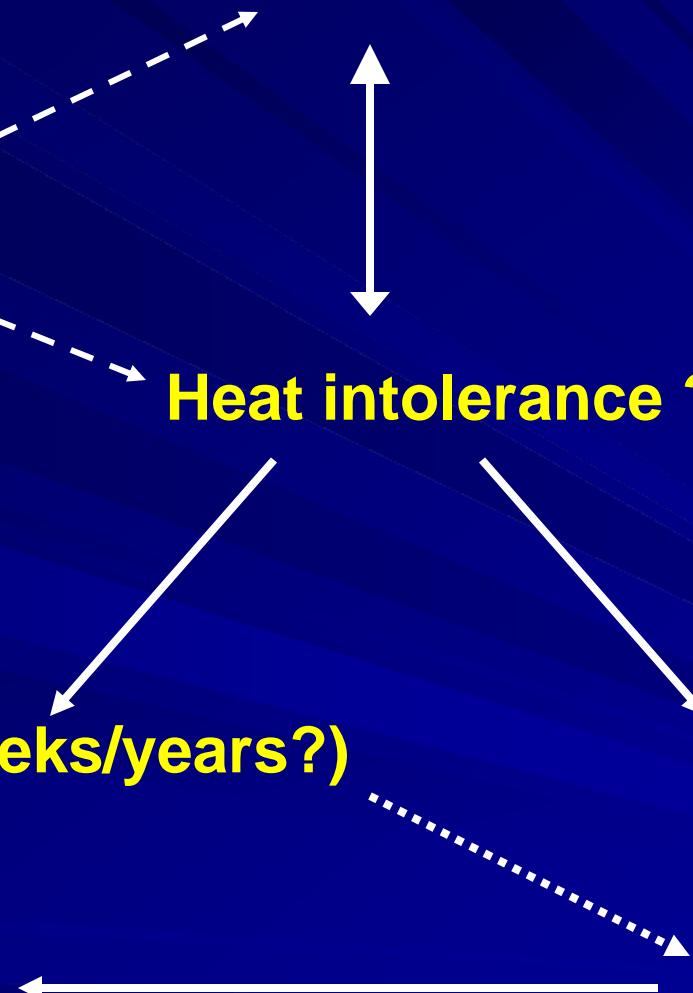
Heat stroke

Preexisting
susceptibility

Heat intolerance ?

Temporary (weeks/years?)

Permanent ?





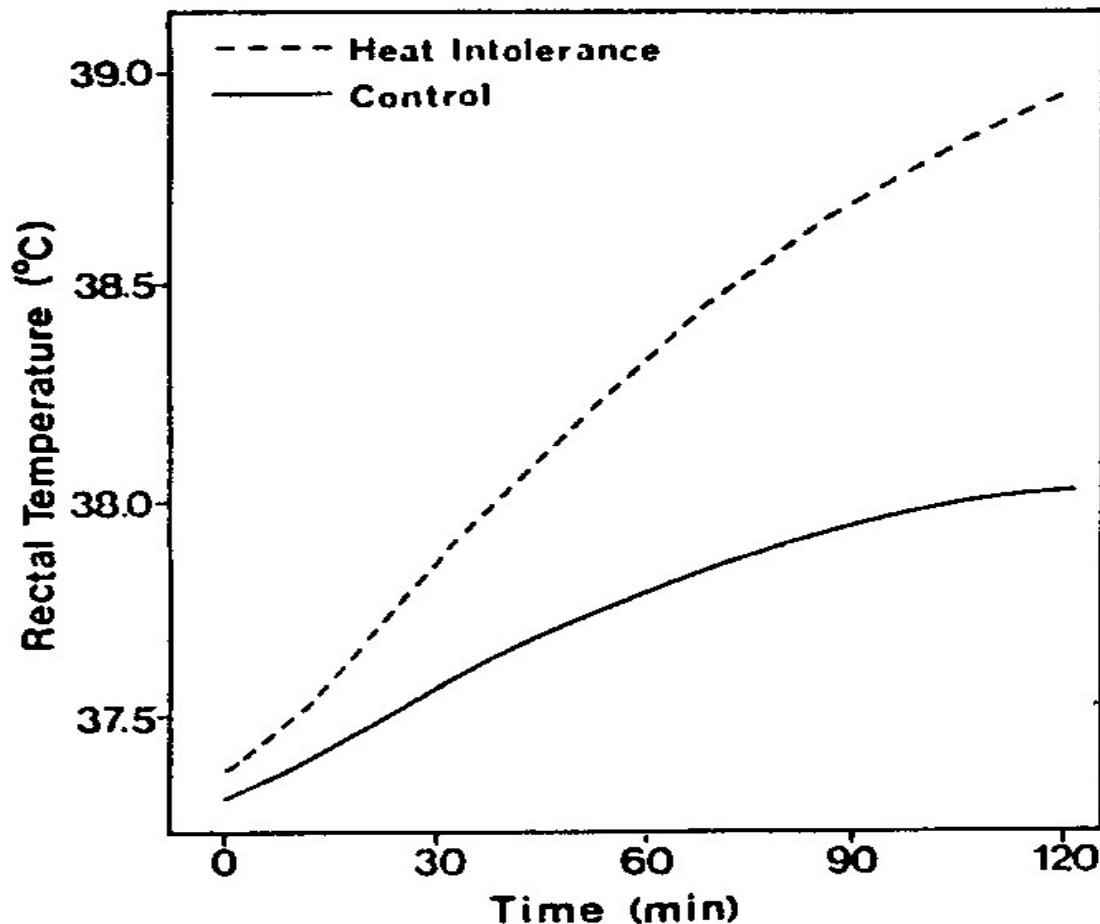
Exercise heat intolerance

- The inability to adapt to work in the heat





Heat tolerance evaluation





Goldmine workers in South Africa

- Hot and very humid conditions
- 90°F (37°C)
- Many heat stroke cases
- Prior acclimatization
- Wyndham et al: 1965- “even after acclimatization there are still large differences between individuals in their temperature reactions to a standard stress of work and heat”
- Wyndham et al: 1973 - “2- 4% of the population was heat intolerant, without manifesting apparent disease process”



Factors underlying heat intolerance



Physiological
perspective

Pathological
perspective



Factors underlying heat intolerance - pathological perspectives

Concurrent disease:

CNS lesions	Sweat gland dysfunction	Extensive burn scar
CV diseases	Hyperthyroidism	Pheochromocytoma
Infectious diseases	Diabetes mellitus	
Psychiatric illness	Parkinsonism	

Congenital abnormalities:

CF	linear skin dystrophy	Ectodermal dysplasia
Scleroderma	Chronic idiopathic anhydrosis	Genetic disorders

Drugs:

Medications	Drug abuse/Supplements	Alcohol
-------------	------------------------	---------



Factors underlying heat intolerance - physiological perspectives

Functional-physiological factors:

Dehydration

Lack of acclimatization

age

Low physical fitness

Obesity (low AD/W)

fatigue

Sleep deprivation

previous heat stroke?

heavy clothing

* Even after correction of these factors, variability still exists!!!!



**Is heat intolerance related to
previous heat stroke?**

**Is heat intolerance temporary or
permanent?**



Case report

Phase 1- Collapse 1

- 19 years old soldier.
- March with 36 kg backpack in a moderate heat load.
- Collapsed after 8 km walk and lost consciousness.
- Treatment included one sprinkle of water and saline infusion.
- Temperature was not measured.
- Clinical picture: weakness, fatigue, diarrhea.
- 15 h after the collapse, patient awoke.
- Neurological sequel: negative.
- Oral temperature: 37.5°C.
- Laboratory examination: blood clotting normal; GOT 293 IU (N=30), CPK 668 IU (N=100), LDH 530 IU (N=350); chest film and ECG – normal.
- Released from hospital after 5 days, clinically recovered with normal enzyme levels.
- Returned to his unit a few days later.



Case report (cont.)

Phase 2 – Collapse 2

Three weeks following the first incident:

- Participated in vigorous march in high heat load.
- After 12 km became confused and irritable and vomited.
- Collapsed and a generalized convulsive seizure was observed.
- Arrived at the hospital within 1 hour of collapse, having been unconscious most of the time
- Rectal T: 39°C; HR 120; BP 120/80; CPK 1252 IU; GPT 277 IU; LDH 1447 IU; GOT 350 IU; clotting and kidney function normal.
- Released from hospital after 4 days, clinically recovered with normal enzymes levels.



Case report (cont.)

Phase 3 – Heat tolerance test 1

After one month (in August), patient went through a heat tolerance test and was diagnosed as heat intolerant

Phase 4 – Heat tolerance test 2

After 5 months (during the winter), patient went through another heat tolerance test and was found to be heat tolerant having normal physiological response



Conclusions

- The second collapse might have been associated with a heat intolerance state caused by prior heat stroke
- Heat stroke might have been the reason for the temporary heat intolerant state





Heat intolerance in former heat stroke patients – study 1

Participants:

- Group 1 -Nine young men who suffered from severe heat stroke and diagnosed as heat intolerant 2 to 5 years before study.
- Group 2 – Ten young control subjects.
- Participants in both groups were sedentary and unacclimatized to heat at time of examination.

Measurements

- Anthropometric
- Orthostatic
- $\text{VO}_{2\text{max}}$
- Heat tolerance test



Heat intolerance in former heat stroke patients - study 1 (cont)

Results:

- No significant differences were found in anthropometric measurements, $\text{VO}_{2\text{max}}$, orthostatic function or sudomotor function.
- All previous heat intolerant subjects were diagnosed as heat intolerant (2-5 years after the first positive test); control subjects were found to be normal.

Conclusion:

- Heat tolerance may last years after heat stroke.
- Was heat stroke associated with preexisting susceptibility ?



Heat intolerance in former heat stroke patients – study 2

Participants:

- Group 1 – Ten participants 60 days post heat stroke.
- Group 2 – Five healthy control participants.
- Participants in both groups were sedentary and unacclimatized to heat at time of examination.

Measurements/Protocol:

- Anthropometric
- $\text{VO}_{2\text{max}}$
- Heat tolerance test
- Nine days heat acclimation



Heat intolerance in former heat stroke patients – study 2 (cont)

Results:

- No significant differences were found in anthropometric and fitness measurements.
- Four prior heat stroke participants (out of 10) were heat intolerant in day 1.
- One prior heat stroke participant was heat intolerant after heat acclimation.

Conclusions:

- Heat tolerance may last months after heat stroke.
- Heat acclimation does not necessarily improve the heat tolerance state in heat intolerance patients.



Recovery from heat stroke

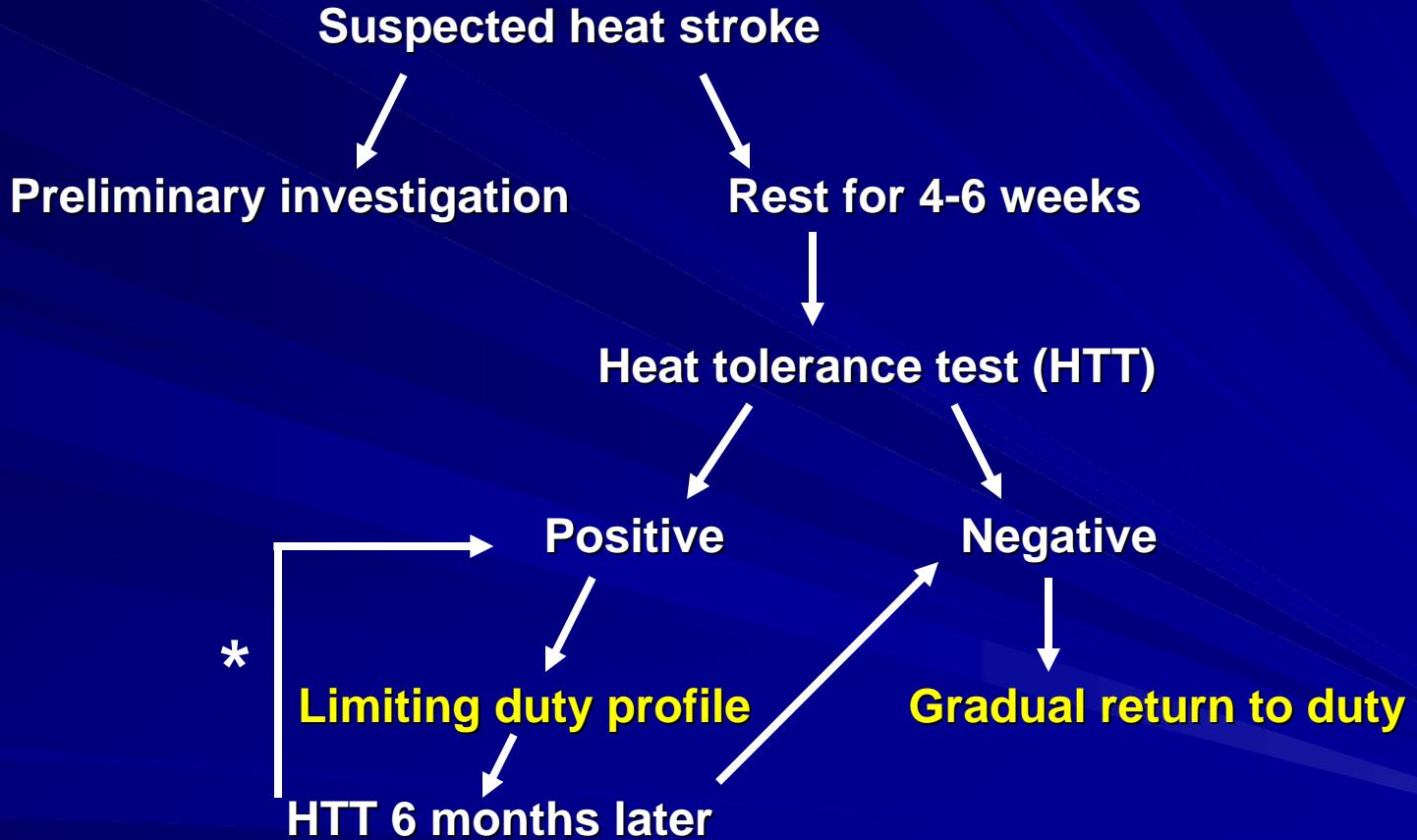
?

When can a subject return to duty/play after heat stroke (if at all)?





The IDF's general regulations for return to duty after heat stroke



* Usually conducted only once, but in special cases, twice or more.



Heat tolerance test (HTT)

Aims:

- To assess the readiness/risk for exercise in hot environments.
- To assess the heat tolerance status of prior heat stroke patient.



Heat tolerance test (HTT)

“HTT was effective in evaluating the heat tolerance status in prior heat stroke subjects”



Heat tolerance test

- 4 to 6 weeks after injury (rest)
- Medical examination
- Questionnaire
- Heat chamber (40°C, 40% RH)
- Walking on treadmill (3.5 mph, 2% slope) for 2 h
- Measures: dynamics/kinetics of Tre, Tsk, HR
- Physiological indices
- Calculation of sweat rate
- Discomfort scale





Heat Intolerance - Criteria

Primary measurements

- Rectal temperature $> 38.5^{\circ}\text{C}$
- No plateau in the dynamics of rectal temperature

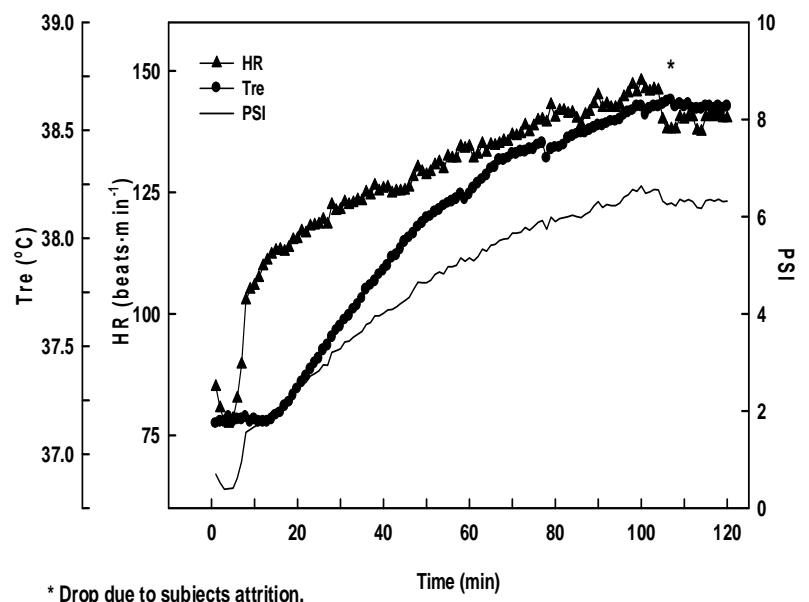
Supportive measurements

- HR $> 150 \text{ bpm}$
- Subjective feeling
- Physiological indices (Physiological Strain Index - PSI and Cumulative Heat Stress Index - CHSI)

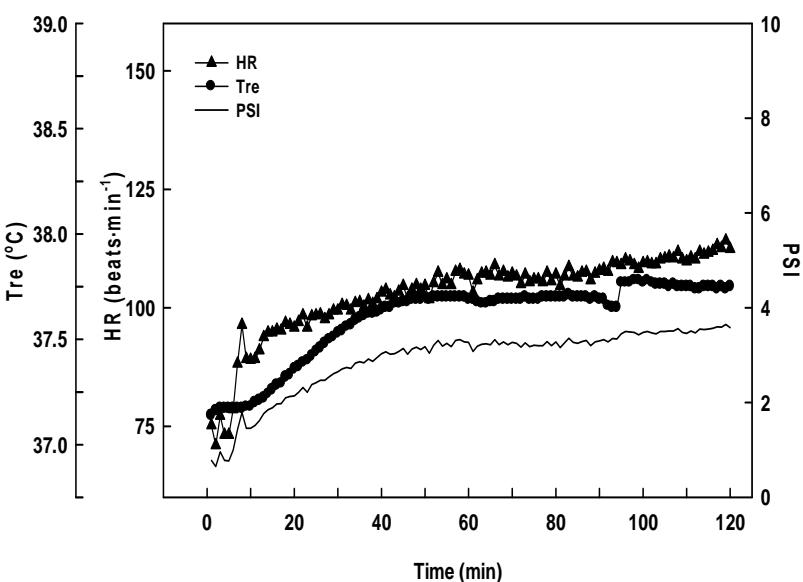


Heat tolerance test

Heat intolerance



Heat tolerance



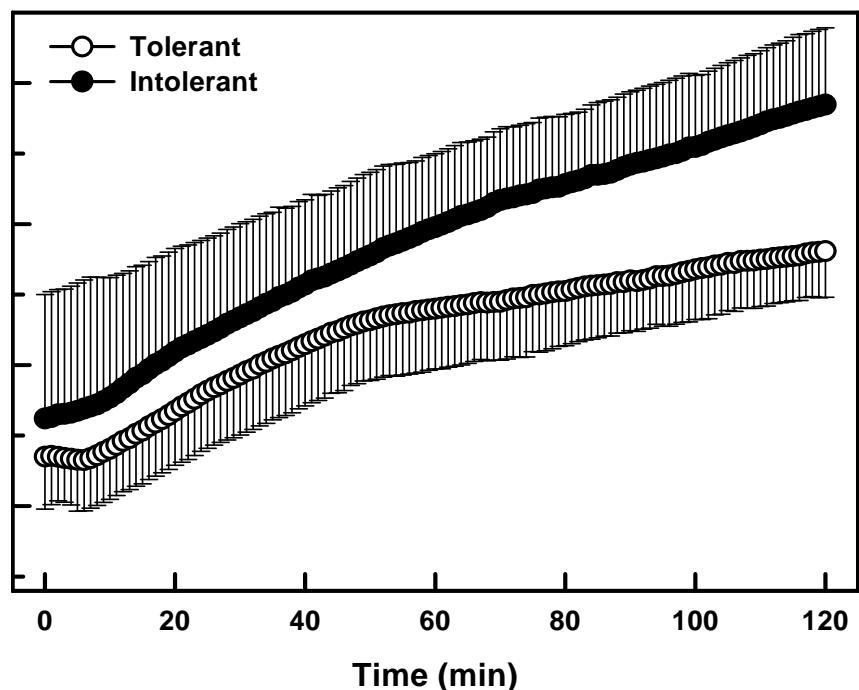
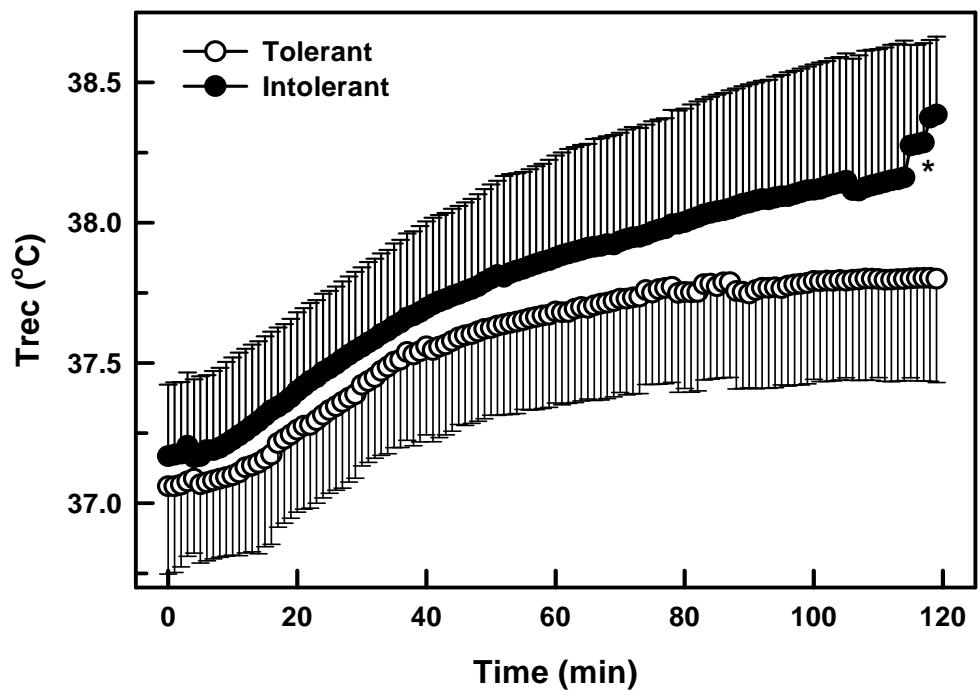


Heat tolerance during 6 months

T = 24
IT = 12

8/12 IT

T = 4
IT = 4



*Due to subject attrition



Assessment of HTT for post heat stroke individuals

Aims:

- To evaluate the HTT for exposure duration and for comfort climate conditions in post exertional heat stroke patients.

Participants:

- 19 post exertional heat stroke males

Measurements/Protocol

- HTT
- Comfort tolerance test (CTT;20°C, 50°RH)
- VO₂
- VO₂ max
- Anthropometry



Assessment of HTT for post heat stroke individuals (cont.)

Results:

- 5 participants (out of 19) were heat intolerant
- No differences in the physiological measures during CTT
- No differences in VO₂ max and VO₂ during the test
- For the heat intolerant group HTT should be 120 min

Conclusions:

- HTT is a reliable test for heat tolerance assessment
- HTT should last 120 min
- CTT is not relevant for heat tolerance assessment

However...some research is still required:

- Borderline cases? - In progress
- Special forces!!! advanced protocols? – In progress
- Different conditions?- In progress
- New mathematical indices for more reliable results – In progress
- Heart rate variability as a supportive measure - In progress
- Mechanisms of heat intolerance-intervention? – In progress



Summary

- ✓ An exertional heat stroke incident may cause heat intolerance for an unpredictable length of time.
- ✓ In most cases, we do not know if the person had suffered from some degree of heat intolerance before the heat injury.
- ✓ One factor that probably influences the duration of heat intolerance after heat stroke is the severity of the heat injury (CNS damage?).
- ✓ A heat tolerance test, after an appropriate rest period, is the only method available for evaluating when a soldier should return to regular training/play in a reasonable time period.
- ✓ Within the IDF, no soldier with a negative (normal physiological response) heat tolerance test (because of a heat stroke event) has experienced a second heat stroke incident.
- ✓ As a result of borderline cases and significantly different fitness levels among soldiers, advanced protocol with more supportive measures may be required.



Thank you